BACKSIDE WEAR OF POLYETHYLENE TIBIAL INSERTS: IS CREEP IMPORTANT?

*Brandt, JM; +*Medley, JB; **McCalden, RW; **MacDonald, SJ; **Rorabeck, CH; **Bourne, RB
+ University of Waterloo, Waterloo, ON, Canada.
**Orthopaedics Division, London Health Sciences Centre, University of Western Ontario, London, ON, Canada.

**Introduction**

Wear particle induced osteolysis has been implicated as a late complication in total knee arthroplasty [1,2]. Wear particles can be produced on both the articular and backside surfaces of ultra high molecular weight polyethylene (PE) tibial inserts. The insidious backside wear is produced by the fretting motion between the tibial tray and the polyethylene inserts caused by slack in the capture mechanism of the tibial tray [2,3]. However, the relative roles of wear and creep on the backside surfaces remain uncertain [3,4]. The present study was derived from a more general study of backside wear [5]. In the more general study, burnished zones were encountered on the periphery of the backside surface. The purpose of the present study was to investigate the relative contributions of creep and wear to the burned zones found on the backside of tibial inserts, thus addressing the issue of whether creep is an important part of the surface damage.

**Methods**

One series of three retrieved AMK (Depuy) tibial inserts (23, 58 and 66 months in vivo) were used in this study. All specimens had evidence of backside damage with the major feature of burnishing [5]. In all cases, the reason for primary joint replacement was osteoarthritis and the reason for removal was instability. These knee implants had polished tibial baseplates without screw holes and mechanical locking devices to hold the PE inserts in place.

Six 3 mm thick sections (three medial, three lateral) were cut out of the backside of the worn area of each implant. The specimen surfaces were examined with scanning electron microscopy (SEM) as well as a contact profilometer (TencorTM-P10) capable of producing scaled contour maps as well as surface roughness profiles. A "melt-annealing" heat treatment, developed by Muratoglu et al [6] was modified to take advantage of the shape memory effect of PE and thus reverse some of the PE creep deformation. Afterwards, the surfaces were examined again using the aforementioned techniques.

**Results**

Specimens taken from the AMK components were deemed to be typical and used to illustrate the findings of the present study. The "as-retrieved" specimen (66 months in vivo) revealed a transition from original machining marks to a relatively smooth burnished zone (Fig. 1a). After melt-annealing, the burnished surface was roughened with a partial recovery of the machining marks that extended from the transition zone deep into the burnished zone (Fig. 1b). Roughness profiles were taken well within the burnished area before and after the melt-annealing (Fig. 2) revealing an increase from $R_{aq} = 0.0138 \pm 0.0233 \, \mu m$ to $R_{aq} = 0.9914 \pm 0.1004 \, \mu m$. Also, it was clear that the burnished area experienced more recovery than the unworn area.

Fig. 1: Polyethylene contours (a) "as-retrieved" (b) after melt-annealing.

**Discussion**

The observed surface contour and profile changes after melt-annealing (Fig. 1 and 2) suggested creep recovery of the polymer. Thus, in the burnished zones creep was responsible for much of the surface change. However, towards the center of the burnished zone, the machining marks did not totally recover, suggesting some amount of wear. Also, the difference in SEM images after melt-annealing (Fig. 3) with the fine ridges and shallow pits suggested that the wear particles were both round and fibril in shape. Both creep and wear were implicated in the formation of the burnished zones on the backside surface of the PE tibial inserts. However, the creep/wear surface changes did not penetrate much beyond the depth of the machining marks in the center of the burnished zone and thus the burnished regions were not evidence of major surface damage. The SEM images of the "as retrieved" burnished zones revealed ripples with wavelengths of about 1 \( \mu m \) and these ripples must be associated with the creep phenomenon.

The present study concluded that creep involving surface micro-ripples, as well as wear, are implicated in the formation of the burnished zones but the extent of the damage remained within the surface asperities.

**References**


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Fig. 2: Surface profiles taken before and after melt-annealing of the surface illustrated in Fig.1 ($y=1.25\,mm$).

At higher magnification, the "as-retrieved" burnished region showed microdamage included ripples (aligned rows of nodules), dispersed smeared nodules and fibril pull-out (Fig. 3a). After melt-annealing, these features disappeared to be replaced by a random pattern of fine ridges and shallow pits (Fig. 3b).

Fig. 3: SEM images (a) "as-retrieved" (b) after melt-annealing.